

– User guide –

D-PorCCA: from acoustics to behaviour

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1. General information

D-PorCCA is a standalone application developed by Dr. Mel Cosentino. D-PorCCA includes with a user-friendly interface. It was developed using App Designer, a MATLAB (Mathworks, MA) development environment that allows to create desktop or web apps that can be used without having a MATLAB account. App Designer was introduced with the 2016a version of MATLAB.

You can use D-PorCCA if you have *.wav* files or the *.pgdf* files generated by PAMGuard's Click Detector Plug In.

2. Installation

Running the executable file will prompt a window to download 'MATLAB Compiler' if not already installed, which is needed for installation. Once D-PorCCA is installed, a short cut will be added to the start menu, after which the user can open the application like any other desktop application or programme.

The current version (May 2020) is the version produced during Dr Cosentino's doctoral project and it likely has errors not yet identified. D-PorCCA will continue to be improved and updated versions made available.

3. Main Display

The application opens on the Main Display (Figure 1). Here, the user can see simultaneously three aspects of the click trains: variations in amplitude, repetition rate or inter-click interval, and centroid frequency or direction of arrival of each click, if available. The menus are available from both tabs.

In the Main Display there are many parameters and functions available to the user, who can also make changes and add notes.

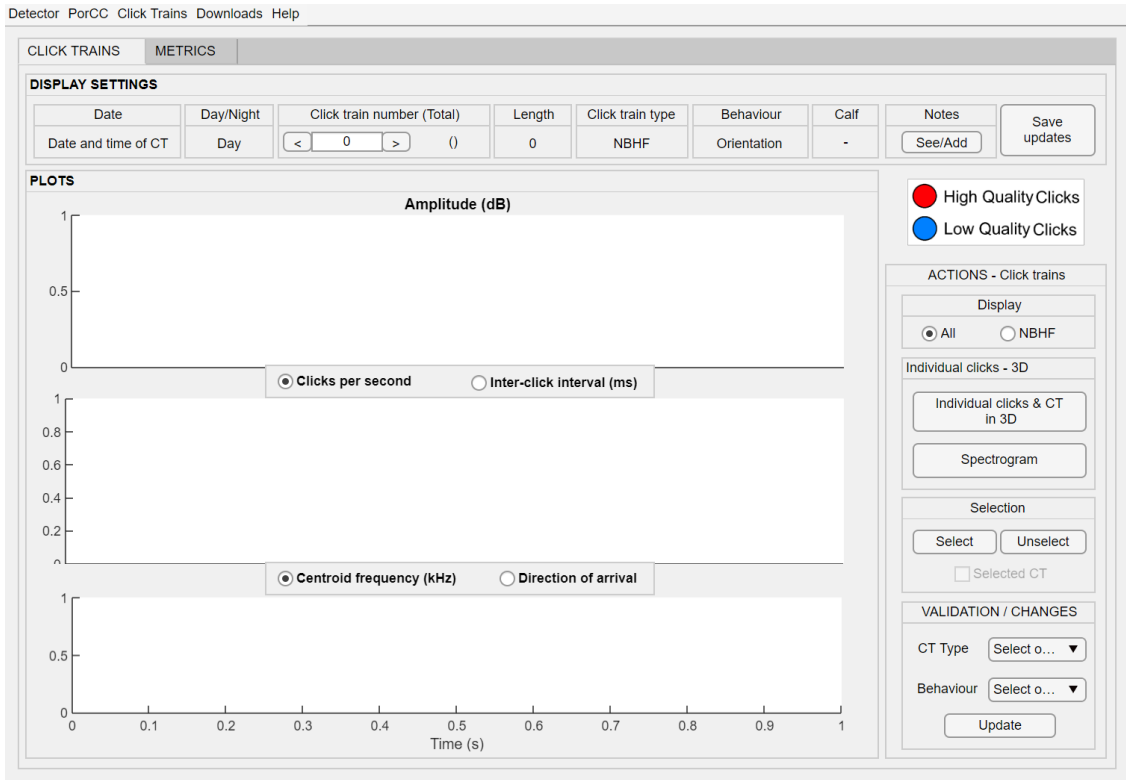


Figure 1. Main page. D-PorCCA main page.

The parameters and functions available in the Main Display are described below:

- ✓ Date and time: date and time of the beginning of the click train.
- ✓ Day/Night: available if the user provides latitude and longitude (in decimal degrees) of the devices. The location is where the device is moored to the seabed or the central location of the study area, in the case of surveys conducted using towed hydrophones. The coordinates are used to estimate sunrise and sunset times of each day for that location using the function 'sunrise' (Beauducel, 2019). Subsequently, this information is used to determine whether the click train was recorded at day or night-time.
- ✓ Length: total number of clicks in the click train.
- ✓ Click train type: there are four categories of click train types: 'NBHF', 'LQ-NBHF', 'Sonar', or 'Non-NBHF'. More information on the decision-making pathway for these categories is provided in Click Trains.
- ✓ Behaviour: there are four behavioural categories: 'Orientation', 'Foraging', 'Socialising', and 'Unknown'. Available for click trains classified as 'NBHF'. More information on how click trains are assigned to either of these categories is provided in Chapter overlap - overlap. Further information and examples of each category are also available in Chapter behaviour - behaviour.

- ✓ Calf: D-PorCCA does not currently include a classifier for young harbour porpoises, however, there is potential to develop such classifier in future work and add it to the application.
- ✓ Notes: add (or see existing) notes for the click train.
- ✓ Save updates: save changes.
- ✓ Display: select to display only 'NBHF' click trains or all types.
- ✓ Individual click trains - 3D: prompt a 3D display (Figure 3). The user can inspect each click individually for verification purposes as well as to visualise specific aspects of it that cannot be appreciated in other ways (e.g., energy content). In this display it is also possible to delete clicks individually.
- ✓ Spectrogram: prompt spectrogram of the click train if the recordings (.wav files) are available.
- ✓ Selection: select individual click trains to extract for further analysis.
- ✓ Validation: change the type and behaviour of the click train manually.

4. Click trains

In D-PorCCA, a click train is defined as a series of consecutive clicks separated by less than a given time period (in ms), which the user can select (default = 1,000 ms). The user can also select the minimum (default = 16 clicks) and maximum (default = 1,500 clicks) number of clicks. Clicks displayed were classified by the PorCC algorithm (Cosentino et al., 2019) as either high-quality (HQ) or low-quality (LQ) clicks, which are seen in red and blue, respectively. Clips classified as 'Noise' are not displayed.

4.1. Click train types

Four click train types are defined.

1. 'NBHF': patterns can be clearly recognised visually and thus are assumed to have been produced by a harbour porpoise or other NBHF species.
2. 'LQ-NBHF': patterns sometimes can be seen but they are not always clear due to high levels of high-frequency background noise or multipath signals.

3. 'Non-NBHF': have no recognisable pattern.
4. 'Sonar': patterned click trains with highly stable repetition rates.

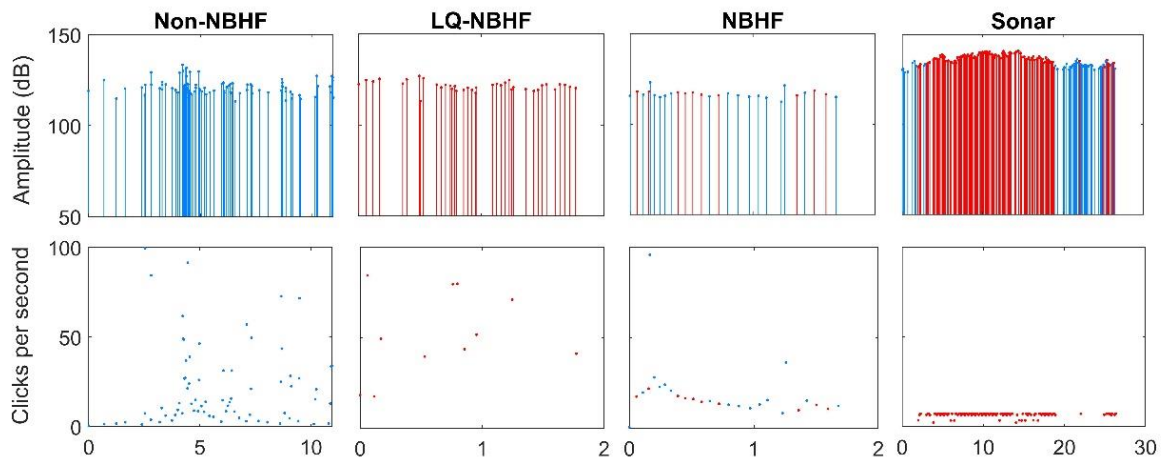


Figure 4.1: Click train types. Example of each click train type. NBHF = narrowband high-frequency. LQ = low quality. The y axis is truncated. The x axis shows time (s). Red = high-quality clicks. Blue = low-quality clicks.

4.2. Click trains in 3D

Pop up window showing a waterfall image of a click train.

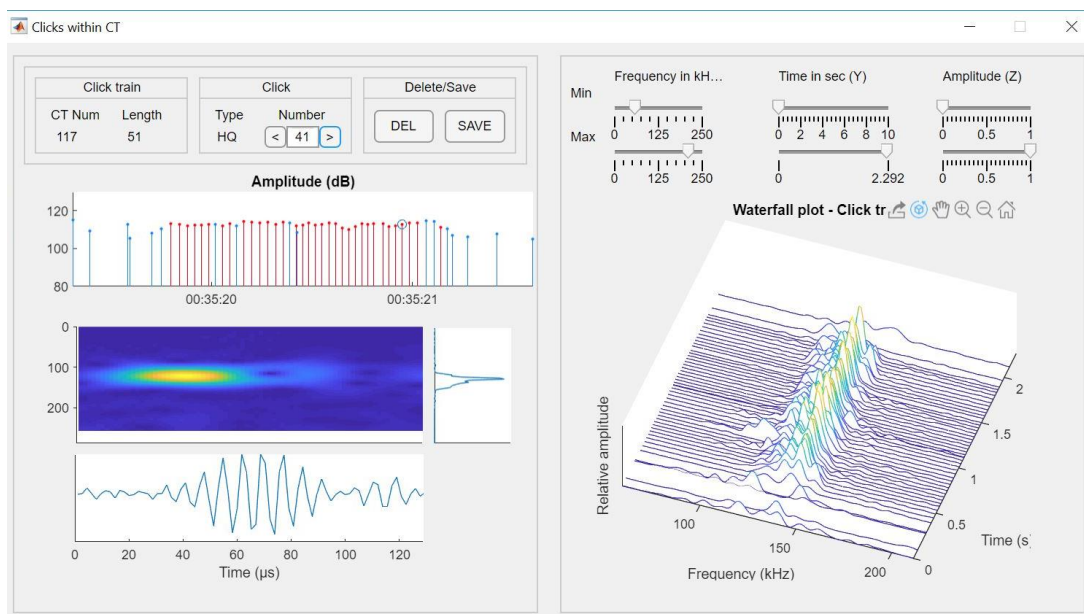


Figure 4.2. Individual click trains. Red = high-quality clicks. Blue = low-quality clicks

Visualising click trains in 3D is useful for verification purposes as the energy content is evident in the power spectrum. Additionally, each click can be inspected, including the waveform, power spectrum, and spectrogram. The user can delete clicks manually from this window if so desires.

5. Behaviour

Four behavioural categories are used in D-PorCCA, which are described below:

- ✓ **'Orientation'**: Orientation refers to the animal moving through their environment, which includes investigating the objects in it (e.g., approaching a rock). This behaviour is characterised by repetition rates below 100 clicks per second (CPS).
- ✓ **'Foraging'**: Foraging events are characterised by three phases: search, approach, and feeding buzz (Au & Hastings, 2008). In the search phase the porpoise produces fewer than 100 CPS; in the approach phase the repetition rate increases rapidly, and the feeding buzz is a final stage of high-production rate that can reach up to 640 CPS (Deruiter et al., 2009).
- ✓ **'Socialising'**: social calls are characterised by not having a period with slow repetition rates as feeding events do.
- ✓ **'Unknown'**: Click trains without a recognisable pattern.

6. Metrics display

Within the Metrics display, there are two sections. On the left side, the user can see a summary table with information about click trains detected in the study period. On the right side, the user can choose between a series of metrics to be displayed (Figure 2). The metrics estimated are described below.

6.1. Metrics

A series of metrics are available as a summary data the user can inspect and download. These metrics were selected because they are already used in the literature or because they provide an easy way to visualise the data.

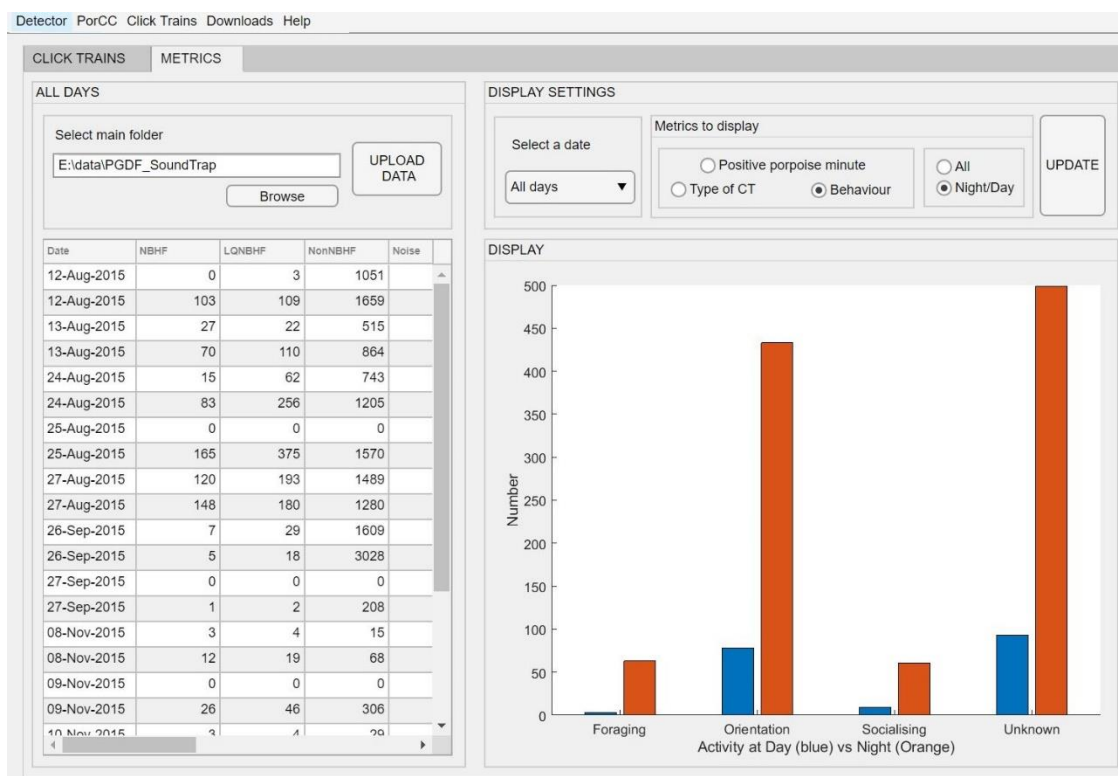


Figure 6.1. Metrics Display. Metrics tab in D-PorCCA.

- **Positive Porpoise Minute:** for each minute of the day, a positive porpoise minute is one where at least a NBHF click train is detected. This metric is available only if the data was collected using a static device. The plot is divided into two parts, one with the total number of positive minutes per day, and the other one plotting each positive minute in the 24 hours of the day.
- **Types of click trains:** four categories of click trains are shown: 'NBHF', 'LQ-NBHF', 'Non-NBHF', and 'Sonar'.
- **Behaviour:** four categories of behaviour are shown: 'Orientation', 'Foraging', 'Socialising', and 'Unknown'.

For each of these metrics, the user can visualise either the total, or the numbers divided into day vs night if available (Figure 6.1). Additionally, the user can select to plot data from the entire survey period or from a specific date. These plots are made from the summary table shown on the left side of the Metrics panel. Lastly, the user can save the plots as *.jpeg* or another format directly from the figure.

7. Menus

D-PorCCA includes a series of Menus to make the user's experience easier.

7.1. Detector

The built-in detector extracts potential clicks from the *.wav* file. The signal is filtered with a 6th order Butterworth band-pass, with the low cut-off frequency set at 2 kHz and the high cut-off frequency at 95% of half of the sampling frequency. These filters are applied to reduce the background noise at low frequencies. In the next step, and to find potential clicks, an adaptive threshold is set based on the first 10,000 samples (*i.e.*, maximum value under 0.1). All peaks over that threshold, separated by at least 200 samples (*i.e.*, 400 μ s for a 500 kHz sampling frequency) are considered potential clicks, and are extracted by adding 120 sample to each side of the peak of the signal. Subsequently, all necessary variables and parameters are estimated, and files constructed to function within D-PorCCA.

This is a very basic detector and the user is advised to use the *.pgdf* files instead.

7.2. PorCC

The user can run the ProCC classifier (Cosentino et al., 2019) by accessing individual clicks directly from the *.pgdf* files generated by PAMGuard's Click Detector Module.

7.2.1. Input values

The user must input a series of parameters for PorCC to function, which are also requested in the Detector menu. These are:

- **Number of hydrophones** or channels used in the recording process.
- **Sampling frequency (kHz) - Fs:** The sampling frequency is the number of samples per second in a sound recording.
- **Hydrophone sensitivity (dB re 1V/1μPa):** is the amplitude (dB re 1μPa) of the sound necessary to generate 1 Volt. This value is provided by the manufacturer and is used to estimate the amplitude of the signals.
- **Gain (dB):** total gain of the recording system. This value is used to estimate the amplitude of the signals.
- **Peak to Peak (Volts):** refers to the clipping value of the recording system. This information is provided by the manufacturer and is use to estimate the amplitude of the given signals.
- **Probability thresholds:** PorCC estimates the probability of a given signal to be a high-quality (HQ) or low-quality (LQ) harbour porpoise (or narrow-band high-frequency - NBHF- click). The probability threshold value in the PorCC Menu is the threshold of selected by the user. The default (and recommended) values for HQ is 0.999999 and for LQ is 0.6.

7.3. Click trains

In this menu, the user can run the algorithms to organise the data (*e.g.*, tables created by the Detector or the PorCC algorithm) into click trains, applying the 'Pattern algorithm' and 'Behaviour algorithm' developed in Chapter overlap - overlap.

Once these algorithms were applied, the user can open existing projects.

7.4. Download

The user is provided with a list of summary data they can download in *.csv* format:

- **Click trains:** Information about each click train is stored in a table, which contains the following parameters: Identification number, date and time, where it is stored (*i.e.*,

.pgdf or *.wav* file), length (number of clicks), day or night time, type, behaviour, selected (0/1), and notes.

- **Summary table:** Summary of parameters for each day (*e.g.*, total number of NBHF click trains).

7.5. Help

In this section, the user can find information about D-PorCCA, and they can search for specific topics, including input values, how to set up the application, and what each of the behaviours represent.

References

- Au, W. W. L., & Hastings, M. (Eds.). (2008). *Principles of marine bioacoustics*. New York: Springer Science+Business Media, LLC. <https://doi.org/10.3397/1.3486045>
- Beauducel, F. (2019). SUNRISE: sunrise and sunset times (<https://www.mathworks.com/matlabcentral/fileexchange/64692-sunrise-sunrise-and-sunset-times>), MATLAB Central File Exchange. Retrieved October 17, 2019.
- Cosentino, M., Guarato, F., Tougaard, J., Nairn, D., Jackson, J. C., & Windmill, J. F. C. (2019). Porpoise click classifier (PorCC): A high-accuracy classifier to study harbour porpoises (*Phocoena phocoena*) in the wild. *The Journal of the Acoustical Society of America*, *145*(6), 3427–3434. <https://doi.org/10.1121/1.5110908>
- Deruiter, S. L., Bahr, A., Blanchet, M.-A., Hansen, S. F., Kristensen, J. H., Madsen, P. T., ... Wahlberg, M. (2009). Acoustic behaviour of echolocating porpoises during prey capture. *The Journal of Experimental Biology*, *212*, 3100–3107. <https://doi.org/10.1242/jeb.030825>
- Wright, A. J., & Tregenza, N. (2019). CPOD successful in trial for detecting Māui dolphin outside harbours. *New Zealand Journal of Marine and Freshwater Research*, *53*(3), 451–459. <https://doi.org/10.1080/00288330.2019.1619597>